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DIGESTIBILITY OF CERTAIN MISCELLANEOUS ANIMAL FATS.[1]

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INTRODUCTION.

Earlier papers[2] of this series have reported the coefficients of digestibility of lard, beef and mutton fats, and butter; cream, chicken, goose, egg-yolk, brisket and fish fats; olive, cottonseed, peanut, coconut and sesame oils and cocoa butter; almond, black-walnut, Brazil nut, butternut, English walnut, hickory nut, and pecan oils; corn, soy-bean, sunflower-seed, Japanese mustard-seed, rapeseed and charlock-seed oils. The present paper deals with the digestibility of goat's butter, kid fat, hard-palate fat, horse fat, oleo oil, oleo stearin, ox-marrow, ox-tail, and turtle fats. Though oleo oil and oleo stearin are of much importance commercially, the fats discussed in this bulletin, as a whole, are not commonly known in American homes. However, they are, for one reason or another, of interest in considering culinary and table fats as well as in the consideration of general problems related to the use of fats as food. A few of these fats were purchased in the open market and the remainder were secured through the cooperation of Government and commercial activities. The hard-palate, horse, kid, and turtle fats were rendered in the laboratory by cutting the unrendered fat very fine, heating in a double boiler until the fat was completely melted, and then straining through rather thick cloth. The oleo oil, oleo stearin, ox-marrow, and ox-tail fats were obtained already rendered from commercial concerns. In order to insure uniform composition a sufficient quantity of each of the fats for the purpose of the study was thoroughly mixed before it was incorporated in the blancmange, which served as a medium for supplying the fat to the diet.

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[1] Prepared under the direction of C. F. Langworthy, Chief, Office of Home Economics.
[2] See list of bulletins on page 26.

METHODS OF PROCEDURE.

The regimen followed was the same as that in previous experiments, foods containing a minimum amount of fat being chosen as a basal diet, i. e., wheat biscuits, oranges, and sugar. The fat to be studied was incorporated in a cornstarch pudding, a caramel solution being added to conceal any pronounced flavor. A sufficient amount of this pudding was prepared for the entire experiment. It was desired that such quantities as were necessary to provide about 100 grams of fat should be eaten by each subject daily, this amount being approximately one-third the total energy of the diet which is the average proportion furnished by fat. Coffee and tea, without cream, were permitted according to individual preference. The experimental diet was eaten for three days or nine meals in each case. This period has been found satisfactory in the previous tests as it is sufficient to give satisfactory results and not so long as to introduce any undesirable physiological effect due to monotony. A 4-days period of normal diet was always followed before beginning a new test.

For separation of the feces from this diet, charcoal was administered in gelatin capsules with the first meal on the fat-containing diet, and with the first meal on resuming the customary diet. The feces were collected in weighed-glass containers, weighed, and then dried in an electric oven at 95° C., pulverized and analyzed. No urine analyses were made and no effort to maintain a nitrogen equilibrium, the digestibility of the fats being the special object of investigation. The coefficients of digestibility of the protein, fat, and carbohydrate supplied by the diet as a whole were determined directly. From these data the digestibility of the fat under consideration was estimated by the method commonly followed and outlined in detail in a previous bulletin.[1] In computing the figure for digestibility of the fat alone, in each experiment correction was made for metabolic products and the small amount of undigested basal ration fat which occurs in the ether extract of the feces.

In general it has been the practice during the study of the digestibility of the edible fats to conduct not less than five tests of three days' duration each. Since the available supply of fat in the case of a number of fats here studied was small, as few as three experiments were made in some instances.

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[1] U. S. Dept. Agr. Bul. 310 (1915), pp. 22.

SUBJECTS.

The subjects were all men who had previously served in the same capacity. They were between 20 and 40 years of age, in good health, and took a moderate amount of exercise. They observed regular hours for meals and followed their normal daily occupations. Since the subjects were students, they would be classed properly as persons engaged in light muscular activities. All were in good physical condition, possessing healthy appetites and normal digestive functions.

GOAT'S BUTTER.

Goat's milk, butter, and cheese have long been common foods in many localities in Europe, yet, aside from chemical analyses, seem to have been little studied. It has long been believed that goat's milk is in some way superior to cow's milk for infant feeding. This belief is probably based on the result of empirical observations for the data found in the literature does not uniformly substantiate such a belief. To obtain more complete data on the relative nutritive values of goat's and cow's milk, Sherman and Lohnes[1] made a comparative study of the two with infants and found that the curds of goat's milk were smaller and more flocculent than those of cow's milk, that goat's milk has finer fat globules and exhibits more thorough emulsification of the fat; that cow's milk has greater stimulating effect on the stomach; that in 16 cases, 12 babies gained more rapidly on cow's milk and 4 more rapidly on goat's milk; that 5 vomited on goat's milk and none on cow's milk; and that children taking goat's milk cried more at night. Bosworth and Van Slyke,[2] who have studied the nature of the casein[3] and soluble and insoluble compounds of goat's milk[4] and compared the composition of cow's, goat's, and human milk,[5] report that goat's milk[6] is less acid, contains a larger amount of chlorids, and that the phosphates are combined with more bases than in cow's milk. Jordan and Smith[6] have made extensive analyses of goat's milk. They concluded that there was no essential difference between the casein, but that there were marked differences in the nature of the ash obtained from cow's and goat's milk. Hall[7] states that goat's milk is palatable, nutritious, easily digested, helpful in certain cases of poor nutrition, and practically free from liability to transmit diseases like tuberculosis.

Very recently Hill[8] has reported a series of chemical analyses of milk produced by a four-months-old virgin doe kid, and states: "The milk was substituted in the diet of an 11-months-old baby for normal goat's milk without any detectable difference either in the appetite or physical condition of the baby."

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[1] Jour. Amer. Med. Assoc., 62 (1914), No. 23, pp. 1806, 1807.

[2] N. Y. State Agr. Expt. Sta. Tech. Bul., 46 (1915), p. 3.

[3] Jour. Biol. Chem., 24 (1916), No. 3, pp. 173–175.

[4] Jour. Biol. Chem., 24 (1916), No. 3, pp. 177–185.

[5] Jour. Biol. Chem., 24 (1916), No. 3, pp. 187–189.

[6] N. Y. State Agr. Expt. Sta. Bul., 429 (1917), p. 4.

[7] N. Y. State Agr. Expt. Sta. Bul., 429 (1917), pop. ed., p. 7.

[8] Jour. Biol. Chem., 33 (1918), No. 3, p. 392.

The literature consulted gave no information as to the presence or absence in goat's milk and butter of the fat-soluble vitamin contained in cow's butter. In view of the use of goat's milk for infant feeding, information on this point would be of especial importance, since goat's milk is in many parts of the world the common household milk supply.

A supply of goat's butter sufficient for the purpose of these experiments was obtained from the Dairy Division of the Bureau of Animal Industry. The butter was of a very pale-yellow color, without pronounced odor or flavor, and by those not informed of its nature it was taken for light-colored dairy butter. Since only a limited supply was available, no tests were made regarding its use in cookery, and the entire sample was incorporated in the usual cornstarch blancmange.

Four experiments were conducted to determine the digestibility of goat's butter and the data which resulted are recorded in the following tables:

Data of digestion experiments with goat's-milk butter in a simple mixed diet.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 645, subject A. F.	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing goat's milk butter.	2,086.0	1,176.4	54.8	144.1	699.0	11.7
Wheat biscuit	245.0	22.0	26.0	3.7	189.4	3.9
Fruit	829.0	720.4	6.6	1.7	96.2	4.1
Sugar	152.0				152.0	
Total food consumed	3,312.0	1,918.8	87.4	149.5	1,136.6	19.7
Feces	76.0		24.8	11.3	31.9	8.0
Amount utilized			62.6	138.2	1,104.7	11.7
Per cent utilized			71.6	92.4	97.2	59.4
Experiment No. 646, subject P. K.:						
Blancmange containing goat's milk butter.	1,809.0	1,020.3	47.4	125.0	606.2	10.1
Wheat biscuit	248.0	22.3	26.3	3.7	191.7	4.0
Fruit	502.0	436.3	4.0	1.0	58.2	2.5
Sugar	191.0				191.0	
Total food consumed	2,750.0	1,478.9	77.7	129.7	1,047.1	16.6
Feces	51.0		18.0	8.1	20.2	4.7
Amount utilized			59.7	121.6	1,026.9	11.9
Per cent utilized			76.8	93.8	98.1	71.7
Experiment No. 647, subject J. C. M.:						
Blancmange containing goat's milk butter.	1,775.0	1,001.1	46.6	122.6	594.8	9.9
Wheat biscuit	316.0	28.4	33.5	4.7	244.3	5.1
Fruit	384.0	333.7	3.1	.8	44.5	1.9
Sugar	175.0				175.0	
Total food consumed	2,650.0	1,363.2	83.2	128.1	1,058.6	16.9
Feces	70.0		23.0	8.6	32.4	6.0
Amount utilized			60.2	119.5	1,026.2	10.9
Per cent utilized			72.4	93.3	96.9	64.5

Data of digestion experiments with goat's-milk butter in a simple mixed diet—Continued.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 648, subject A. A. R.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing goat's milk butter	1,770.0	998.3	46.4	122.3	593.1	9.9
Wheat biscuit	192.0	17.3	20.3	2.9	148.4	3.1
Fruit	1,059.0	920.3	8.5	2.1	122.8	5.3
Sugar	210.0				210.0	
Total food consumed	3,231.0	1,935.9	75.2	127.3	1,074.3	18.3
Feces	71.0		25.0	6.6	33.0	6.4
Amount utilized			50.2	120.7	1,041.3	11.9
Per cent utilized			66.8	94.8	96.9	65.0
Average food consumed per subject per day	995.3	558.1	27.0	44.6	359.7	6.0

Summary of digestion experiments with goat's-milk butter in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of goat's milk butter alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
645	A. F	71.6	92.4	97.2	59.4	97.4
646	P. K	76.9	93.8	98.1	71.7	97.5
647	J. C. M	72.4	93.3	96.9	64.5	98.6
648	A. A. R	66.8	94.8	96.9	65.0	100.0
Average		71.9	93.6	97.3	65.2	98.4

Considering the diet as a whole, the subjects ate on an average 27 grams of protein, 45 grams of fat, and 360 grams of carbohydrate daily, which supplied approximately 2,079 calories of energy. Since the available amount of goat's butter was small, only about 45 grams of fat, of which about 43 grams was goat's butter, was eaten daily. The digestibility was found to be 71.9 per cent for protein, 93.6 per cent for fat, and 97.3 per cent for the carbohydrate supplied by the diet as a whole. When correction is made for the metabolic products and undigested basal-ration fat which occurs in the ether extract of the feces, the figure 93.6 per cent for the digestibility of the total fat of the diet becomes 98.4 per cent for the digestibility of goat's butter alone.

For the sake of comparison it is of interest in this connection to refer to the figure for the digestibility of cow's butter[1] determined under conditions identical with those maintained for the experiments here reported. This was found to be 97 per cent, a difference, which for all practical dietetic purposes is negligible as compared with 99 per cent, the digestibility of goat's butter. Since all the subjects reported that they were in normal physical condition during the entire period of these experiments, it appears that goat's butter is a wholesome valuable food fat.

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[1] U. S. Dept. Agr. Bul. 310 (1915), p. 21.

KID FAT.

The consumption of kid fat is quite limited in this country, being confined largely to those of foreign birth and food habits, who include goat or kid meat in their dietary. Just as the consumption of lamb greatly exceeds that of mutton, the amount of kid meat eaten exceeds that of goat meat. Kid fat has little if any sale in this country as an edible fat; however, it seemed of interest to compare its digestibility with that of mutton fat.

Through the courtesy of the Bureau of Animal Industry, one-half of the carcass of a 6-months-old kid was secured for experimental purposes. The kidney fat and all of the superficial fat was carefully removed, finely cut, and rendered in a double boiler. The meat was cooked and its digestibility determined by means of the usual digestion experiments, the results of which are reserved for future discussion. The fat which cooked out of the meat was carefully saved and, since it had not been scorched and was free from any suspended matter, was added to the rendered kidney fat in order that a sufficient quantity of fat should be available for the experiments reported below.

Data of digestion experiments with kid fat in a simple mixed diet.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 712, subject P. K.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing kid fat	1,506.0	813.1	27.7	177.0	476.5	11.7
Wheat biscuit	319.0	28.7	33.8	4.8	246.6	5.1
Fruit	492.0	427.5	3.9	1.0	57.1	2.5
Sugar	197.0				197.0	
Total food consumed	2,514.0	1,269.3	65.4	182.8	977.2	19.3
Feces	72.0		7.0	16.5	41.9	6.6
Amount utilized			58.4	166.3	935.3	12.7
Per cent utilized			89.3	91.0	95.7	65.8
Experiment No. 713, subject J. C. M.:						
Blancmange containing kid fat	1,641.0	886.0	30.2	192.8	519.2	12.8
Wheat biscuit	388.0	34.9	41.2	5.8	299.9	6.2
Fruit	1,013.0	880.3	8.1	2.0	117.5	5.1
Sugar	149.0				149.0	
Total food consumed	3,191.0	1,801.2	79.5	200.6	1,085.6	24.1
Feces	69.0		2.3	9.7	50.9	6.1
Amount utilized			77.2	190.9	1,034.7	18.0
Per cent utilized			97.1	95.2	95.3	74.7

Data of digestion experiments with kid fat in a simple mixed diet—Continued.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 714, subject A. A. R.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing kid fat	1,428.0	771.0	26.3	167.8	451.8	11.1
Wheat biscuit	237.0	21.3	25.1	3.6	183.2	3.8
Fruit	1,204.0	1,046.3	9.6	2.4	139.7	6.0
Sugar	168.0	....	....	....	168.0	....
Total food consumed	3,037.0	1,838.6	61.0	173.8	942.7	20.9
Feces	104.0	....	13.1	21.4	59.4	10.1
Amount utilized	....	....	47.9	152.4	883.3	10.8
Per cent utilized	....	....	78.5	87.7	93.7	51.7
Average food consumed per subject per day	971.3	945.5	22.9	61.9	333.9	7.1

Summary of digestion experiments with kid fat in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of kid fat alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Percent.*	*Per cent.*	*Per cent.*	*Per cent.*
712	P. K.	89.3	91.0	95.7	65.8	94.1
713	J. C. M.	97.1	95.2	95.3	74.7	98.4
714	A. A. R.	78.5	87.7	93.7	51.7	93.4
Average		88.3	91.3	94.9	64.1	95.3

The coefficients of digestibility of the diet as a whole were found to be 88.3 per cent for protein, 91.3 per cent for fat, 94.9 per cent for carbohydrate, and the estimated digestibility of kid fat alone is 95.3 per cent. This figure obtained for the digestibility of kid fat is perhaps not directly comparable with the coefficient of digestibility, 88 per cent, previously reported[1] for mutton fat, since the mutton fat was kidney fat and the kid fat was a mixed fat obtained from all parts of the carcass, and as has been previously noted,[2] the nature of fat varies somewhat with the part of the body from which it is taken. Though a little lower it compares very favorably in digestibility with goat's butter which was 99 per cent digested. The average amount of kid fat eaten daily, 62 grams, was somewhat in excess of 53 grams, the average daily consumption of mutton fat.

In the reports of their physical condition during the test period, none of the subjects made any mention of any laxative effect or other digestive disturbances resulting from the experimental diet, and accordingly on the basis of the experiments here reported, it may be assumed that kid fat, when eaten in amounts not in excess of 60 grams daily is quite well assimilated and is suited for use as human food.

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[1] U. S. Dept. Agr. Bul. 310 (1915), p. 21.

[2] U. S. Dept. Agr. Bul. 507 (1917), p. 9.

HARD-PALATE FAT.

The so-called "hard palates" are taken from the roof of the mouth of beef animals. In appearance they are very unattractive, possessing a black or white, rough, ribbed outer surface, and contain little muscular tissue. According to information obtained from the Bureau of Animal Industry,[1] several of the large packing establishments utilize the hard palates of cattle in the preparation of edible products, such as potted meats, sausage, etc. One establishment is reported as saving about 2,500 pounds monthly, another about 6,000 pounds monthly. In view of this rather extensive use of hard palates for food purposes, it appeared very desirable to ascertain the digestibility of this material, and accordingly seven experiments were conducted in this laboratory, and it was found that the protein was approximately 87 per cent digested.[2] Some attention was paid also to the fat of the hard palates, and its possible uses for culinary purposes emphasized the desirability of studying its digestibility.

In the preparation of the hard palates for use in the experiments referred to they were boiled for two to three hours, a yellow fat being extracted during the process. While hard palates contain only a small amount of this fat—about 11 per cent—of which approximately one-half is extracted by boiling the hard palates for two or three hours, the total yield of packing houses preparing two or three tons per month of hard palates for edible purposes is evidently of commercial importance.

The hard-palate fat used in this study was obtained by boiling palates for two or three hours in a large amount of water. About 100 pounds of fresh hard palates secured from a local abattoir were extracted in this manner. The fat, which floated to the top of the liquor, hardened on cooling and was removed and purified by remelting several times in boiling water. It had a yellow color, was without characteristic taste, and resembled butter somewhat in appearance, though it was more granular.

As previously reported,[3] it was found to have a melting point of 34° C., an iodin number of 52.53, and a refractive index of 1.4586.

Three subjects assisted in the study of this fat. The results of the tests are reported in the following tables:

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[1] Personal communication.

[2] Digestibility of Hard Palates of Cattle, Jour. Agr. Research, 6 (1916), No. 17.

[3] Loc. cit.

Data of digestion experiments with hard-palate fat in a simple mixed diet.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash
Experiment No. 574, subject A. J. H.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing hard-palate fat	1,329.0	522.8	24.1	201.7	569.1	11.3
Wheat biscuit	87.0	7.8	9.2	1.3	67.3	1.4
Fruit	305.0	265.1	2.4	0.6	35.4	1.5
Sugar	65.0				65.0	
Total food consumed	1,786.0	795.7	35.7	203.6	736.8	14.2
Feces	75.0		25.7	22.8	18.8	7.7
Amount utilized			10.0	180.8	718.0	6.5
Per cent utilized			28.0	88.8	97.4	45.8
Experiment No. 575, subject P. K.:						
Blancmange containing hard-palate fat	1,924.0	756.9	34.8	292.1	823.9	16.3
Wheat biscuit	357.0	32.1	37.8	5.4	276.0	5.7
Fruit	861.0	748.2	6.9	1.7	99.9	4.3
Sugar	69.0				69.0	
Total food consumed	3,211.0	1,537.2	79.5	299.2	1,268.8	26.3
Feces	82.0		26.0	27.2	20.2	8.6
Amount utilized			53.5	272.0	1,248.6	17.7
Per cent utilized			67.3	90.9	98.4	67.3
Experiment No. 576, subject C. J. W.:						
Blancmange containing hard-palate fat	1,949.0	766.7	35.3	295.9	834.5	16.6
Wheat biscuit	341.0	30.7	36.1	5.1	263.6	5.5
Fruit	1,011.0	878.6	8.1	2.0	117.3	5.0
Sugar	81.0				81.0	
Total food consumed	3,382.0	1,676.0	79.5	303.0	1,296.4	27.1
Feces	110.0		33.9	25.2	37.1	13.8
Amount utilized			45.6	277.8	1,259.3	13.3
Per cent utilized			57.4	91.7	97.1	49.1
Average food consumed per subject per day	931.0	445.5	21.6	89.5	366.9	7.5

Summary of digestion experiments with hard-palate fat in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of hard-palate fat alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
574	A. J. H	28.0	88.8	97.4	45.8	92.4
575	P. K	67.3	90.9	98.4	67.3	93.5
576	C. J. W	57.4	91.7	97.1	49.1	95.2
Average		50.9	90.5	97.6	54.1	93.7

It will be noted on referring to the above tables that the subjects ate on an average 22 grams of protein, 90 grams of fat, and 367 grams of carbohydrate daily, which had a fuel value of 2,366 calories. The protein, fat, and carbohydrate supplied by the total diet were 50.9 per cent, 90.5 per cent, and 97.6 per cent digested, respectively. When corrections are made for the metabolic products and undigested fat resulting from the basal ration occurring in the feces the value, 90.5

per cent, for the digestibility of the total fat of the diet becomes 93.7 per cent for the digestibility of the hard-palate fat.

The subjects all reported that they were in normal physical condition during the period of these experiments, and accordingly it appears that hard-palate fat of good quality may be eaten as a constituent of a simple mixed diet at least in amounts not exceeding 90 grams daily without physiological disturbances.

HORSE FAT.

At present horse flesh is sold for human food in this country in only a few of the larger cities. That the supply of animals exceeds the demand[1] is shown by letters received by commission firms in Chicago from Montana ranchmen offering in carload lots animals that were "overaged," "wire cut," "undersized," and "inbred," but in "good flesh and health." Horse flesh is quite generally used for human food in some European countries, for it is reported[2] that as long ago as 1892 in Paris and Vienna over 20,000 horses were slaughtered for human food. "Similar statistics are furnished also from Berlin and other public abattoirs in Prussia, and the supply of horse flesh as a meat food for the public has become a regular and well-organized business." In 1910, 29,000,000 pounds of horse meat[3] was produced for consumption in Paris and its environs. In Germany, in 1909, 152,214 horses were slaughtered, which provided 79,000,000 pounds of meat; approximately 1½ pounds per capita.

It is apparent from these statements that horse fat as a part of the meat enters into the European dietary. It is evidently also known as a separated fat, for Lewkowitsch[4] reports that "it is used by the poorer classes on the Continent as an edible fat in the place of lard, and is no doubt used as an adulterant of more expensive fats." There is a tradition in some foreign countries that it has a special value as shortening in pastry making.

Though no definite information regarding its use for such purposes in the United States has been found, it seemed not without interest to include a study of horse fat, and in order that the results obtained might be directly comparable with those obtained for beef, mutton, and pork (kidney fats), reported in an earlier paper,[5] an attempt was made to secure a supply of horse-kidney fat. However, after several horses had been slaughtered without securing from any sufficient kidney fat for the purpose of this study, it was decided to study a composite fat taken from different parts of the body. Through the courtesy of Superintendent Hollister, of the National Zoological Park, a supply of horse fat (neck and leaf) was secured from a healthy inspected animal, such as are regularly procured to supply food for the carnivorous animals confined in the park. In the unrendered form its physical appearance was so similar to that of beef fat that the members of the laboratory staff who were unaware of its source assumed it to be beef fat. Samples of the neck and leaf fats which were analyzed by R. H. Kerr, of the Bureau of Animal Industry, were found to have the following constants: Neck fat, iodin number 95.83 and refractive index at 40° C. 55.5° and leaf fat, iodin number 91.22 and refractive index at 40° C. 54.0°. The unrendered fats were passed through a meat cutter, uniformly mixed, and rendered in a double boiler. The rendered fat on standing tended to separate into an oily and solid layer, resembling chicken fat in this respect.

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[1] Nat. Provisioner, 58 (1918), No. 16, p. 17.

[2] Lancet [London], 1 (1918), No. 5, p. 189.

[3] Jour. Amer. Vet. Med. Assoc., n. ser., 4 (1917), No. 5, p. 681.

[4] Chemical Technology and Analysis of Oils, Fats, and Waxes, II. J. Lewkowitsch, London: Macmillan and Co. (1909), j. 547.

[5] U. S. Dept. Agr. Bul. 310 (1915).

Three subjects assisted in the experiments, which are reported in the tables which follow:

Data of digestion experiments with horse fat in a simple mixed diet.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 747, subject P. K.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing horse fat	1,634.0	734.2	33.0	184.0	669.1	13.7
Wheat biscuit	304.0	27.4	32.2	4.5	235.0	4.9
Fruit	514.0	446.7	4.1	1.0	59.6	2.6
Sugar	265.0	....	....	....	265.0	....
Total food consumed	2,717.0	1,208.3	69.3	189.5	1,228.7	21.2
Feces	67.0	....	22.3	9.4	29.9	5.4
Amount utilized	....	....	47.0	180.1	1,198.8	15.8
Per cent utilized	....	....	67.8	95.0	97.6	74.5
Experiment No. 748, subject M. L. M.:						
Blancmange containing horse fat	1,670.0	750.3	33.7	188.1	683.9	14.0
Wheat biscuit	558.0	50.2	59.2	8.4	431.3	8.9
Fruit	667.0	579.6	5.4	1.3	77.4	3.3
Sugar	429.0	....	....	....	429.0	....
Total food consumed	3,324.0	1,380.1	98.3	197.8	1,621.6	26.2
Feces	133.0	....	40.8	13.2	68.3	10.7
Amount utilized	....	....	57.5	184.6	1,553.3	15.5
Per cent utilized	....	....	58.5	93.3	95.8	59.2
Experiment No. 749, subject J. C. M.:						
Blancmange containing horse fat	1,719.0	772.4	34.7	193.6	703.9	14.4
Wheat biscuit	385.0	34.6	40.8	5.8	297.6	6.2
Fruit	948.0	823.8	7.6	1.9	110.0	4.7
Sugar	194.0	....	....	....	194.0	....
Total food consumed	3,246.0	1,630.8	83.1	201.3	1,305.5	25.3
Feces	123.0	....	37.4	15.3	59.8	10.5
Amount	....	....	45.7	186.0	1,245.7	14.8
Per cent utilized	....	....	55.0	92.4	95.4	58.5
Average food consumed per subject per day	1,032.0	468.8	27.9	65.4	461.8	8.1

Summary of digestion experiments with horse fat in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of horse fat alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
747	P. K.	67.8	95.0	97.6	74.5	95.2
748	M. L. M.	58.5	93.3	95.8	59.2	93.7
749	J. C. M.	55.0	92.4	95.4	58.5	92.7
Average		60.4	93.6	96.3	64.1	93.9

The fat-rich blancmange containing horse fat formed the predominating part of a simple mixed diet and was eaten without comment, indicating that this blancmange was as acceptable as that served in other experiments of a similar nature. All the subjects stated, in the reports which they submitted regarding their physical condition during the experimental period, that they continued in normal health.

On an average the subjects ate 28 grams of protein, 65 grams of fat, and 462 grams of carbohydrate daily, which supplied 2,545 calories of energy. The coefficients of digestibility of the diet as a whole were for protein 60.4 per cent, for fat, 93.6 per cent, and for the carbohydrate 96.3 per cent. If correction for the metabolic products and undigested basal ration fat is applied to the figure 93.6 per cent, the digestibility of the total fat of the diet, it is found that the coefficient of digestibility of horse fat alone is 93.9 per cent. This figure, 93.9 per cent, is for dietetic purposes the same as 93 per cent reported[1] in an earlier paper for the digestibility of beef-kidney fat. It is higher than the digestibility reported from similar experiments with mutton-kidney fat[1] (88 per cent), and somewhat lower than the digestibility of lard[1] (97 per cent), butter[1] (97 per cent), and beef-brisket fat[2] (97.4 per cent).

On the basis of these experiments it appears that rendered horse fat obtained from healthy animals when eaten as a part of a simple mixed diet in amounts not exceeding 65 grams daily produces no physiological disturbances and was well utilized by the human body.

OLEO OIL.

Beef tallow, like other edible fats, consists essentially of olein, palmitin, and stearin. In order to utilize most efficiently the enormous quantities of beef tallow that result from the slaughter of cattle in this country yearly, it has been found satisfactory to separate the beef tallow into soft (oleo oil) and hard (oleo stearin) fats. The commercial manufacture of oleo oil and oleo stearin is, in brief, as follows: The rough fat from the slaughtered animal is washed with warm water, hardened naturally or by immersing in ice water. The hardened fat is finely cut, rendered in tin-lined jacketed vessels, and allowed to stand for a time in a crystallizing room, the temperature of which is carefully regulated, after which it is subjected to hydraulic pressure. The soft oleo oil runs out of the press and the hard oleo stearin remains in the press. Though they have very extensive commercial uses, oleo oil and oleo stearin are little known to the housekeeper.

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[1] U. S. Dept. Agr. Bul. 310 (1915), p. 21.

[2] U. S. Dept. Agr. Bul. 507 (1917), p. 18.

While both the oleo oil and oleo stearin are used as constituents of compounded fats, designed for table and culinary purposes, oleo oil is also used as a separated fat by persons who, because of national or religious customs, prefer it to other types of animal fats. Oleo oil is also used in large quantities in the manufacture of oleomargarin.

The oleo oil which was studied in the experiments here reported was obtained from a dealer in edible fats and was held to be representative of commercial oleo oil. In appearance it was a light yellow fat of about the same consistency as butter, solid at ordinary room temperature, and without distinctive odor or taste.

The results which were obtained with oleo oil are included in the following tables:

Data of digestion experiments with oleo oil in a simple mixed diet.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 805, subject J. F. C.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing oleo oil	1,125.0	500.7	19.7	146.8	449.2	8.6
Wheat biscuit	377.0	33.9	40.0	5.7	291.4	6.0
Fruit	1,316.0	1,143.6	10.5	2.6	152.7	6.6
Sugar	310.0				310.0	
Total food consumed	3,128.0	1,678.2	70.2	155.1	1,203.3	21.2
Feces	88.0		23.8	13.3	43.1	7.8
Amount utilized			46.4	141.8	1,160.2	13.4
Per cent utilized			66.1	91.4	96.4	63.4
Experiment No. 806, subject T. G. H.:						
Blancmange containing oleo oil	1,482.0	659.6	25.9	193.4	591.8	11.3
Wheat biscuit	84.0	7.6	8.9	1.3	64.9	1.3
Fruit	1,468.0	1,275.7	11.8	2.9	170.3	7.3
Sugar	199.0				199.0	
Total food consumed	3,233.0	1,942.9	46.6	197.6	1,026.0	19.9
Feces	123.0		35.4	24.9	52.3	10.4
Amount utilized			11.2	172.7	973.7	9.5
Per cent utilized			24.0	87.4	94.9	47.7

Data of digestion experiments with oleo oil in a simple mixed diet—Continued.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 807, subject P.K.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing oleo oil	1,201.0	534.6	21.0	156.7	479.6	9.1
Wheat biscuit	300.0	27.0	31.8	4.5	231.9	4.8
Fruit	291.0	252.9	2.3	.6	33.7	1.5
Sugar	293.0	....	....	....	293.0	....
Total food consumed	2,085.0	814.5	55.1	161.8	1,038.2	15.4
Feces	63.0	....	18.2	14.7	23.4	6.7
Amount utilized	....	....	36.9	147.4	1,013.8	8.7
Per cent utilized	....	....	67.0	90.9	97.7	56.5
Experiment No. 808, subject G. S. M.:						
Blancmange containing oleo oil	1,368.0	608.9	23.9	178.5	546.3	10.4
Wheat biscuit	346.0	31.1	36.7	5.2	267.5	5.5
Fruit	1,350.0	1,173.1	10.8	2.7	156.6	6.8
Sugar	415.0	....	....	....	415.0	....
Total food consumed	3,479.0	1,813.1	71.4	186.4	1,385.4	22.7
Feces	152.0	....	42.0	15.2	81.5	13.3
Amount utilized	....	....	29.4	171.2	1.303.9	9.4
Per cent utilized	....	....	41.2	91.8	94.1	41.4
Experiment No. 809, subject D. D. M.:						
Blancmange containing oleo oil	1,366.0	608.0	23.9	178.3	545.4	10.4
Wheat biscuit	623.0	56.1	66.0	9.3	481.6	10.0
Fruit	1,310.0	1,138.4	10.5	2.6	152.0	6.5
Sugar	414.0	....	....	....	414.0	....
Total food consumed	3,713.0	1,802.5	100.4	190.2	1,593.0	26.9
Feces	128.0	....	37.3	14.2	65.1	11.4
Amount utilized	....	....	63.1	176.0	1.527.9	15.5
Per cent utilized	....	....	62.8	92.5	95.9	57.6
Experiment No. 810, subject M. L. M.:						
Blancmange containing oleo oil	1,267.0	563.9	22.2	165.4	505.9	9.6
Wheat biscuit	366.0	32.9	38.8	5.5	282.9	5.9
Fruit	1,152.0	1,001.1	9.2	2.3	133.6	5.8
Sugar	401.0	....	....	....	401.0	....
Total food consumed	3,186.0	1,597.9	70.2	173.2	1,323.4	21.3
Feces	99.0	....	33.7	14.6	42.0	8.7
Amount utilized	....	....	36.5	159.6	1.281.4	12.6
Per cent utilized	....	....	52.0	91.6	96.8	59.2
Experiment No. 811, subject J. C. M.:						
Blancmange containing oleo oil	1,162.0	517.2	20.3	151.7	464.0	8.8
Wheat biscuit	426.0	38.3	45.2	6.4	329.3	6.8
Fruit	1,243.0	1,080.2	9.9	2.5	144.2	6.2
Sugar	135.0	....	....	....	135.0	....
Total food consumed	2,966.0	1,635.7	75.4	160.6	1,072.5	21.8
Feces	93.0	....	24.3	15.2	43.2	10.3
Amount utilized	....	....	51.1	145.4	1.029.3	11.5
Per cent utilized	....	....	67.8	90.5	96.0	52.8
Experiment No. 812, subject W. O'C.:						
Blancmange containing oleo oil	1,476.0	657.0	25.8	192.6	589.4	11.2
Wheat biscuit	191.0	17.2	20.2	2.9	147.6	3.1
Fruit	1,125.0	977.6	9.0	2.3	130.5	5.6
Sugar	467.0	....	....	....	467.0	....
Total food consumed	3,259.0	1,651.8	55.0	197.8	1,334.5	19.9
Feces	119.0	....	32.1	25.0	48.4	13.5
Amount utilized	....	....	22.9	172.8	1.286.1	6.4
Per cent utilized	....	....	41.6	87.4	96.4	32.2
Average food consumed per subject per day	1,043.7	539.0	22.7	59.3	415.7	7.0

Summary of digestion experiments with oleo oil in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of oleo oil alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
805	J. F. C.	66.1	91.4	96.4	63.4	96.9
806	T. G. H.	24.0	87.4	94.9	47.7	93.4
807	P. K.	67.0	90.9	97.7	56.5	94.6
808	G. S. M.	41.2	91.8	94.1	41.4	99.9
809	D. D. M.	62.8	92.5	95.9	57.6	99.1
810	M. L. M.	52.0	91.6	96.8	59.2	97.1
811	J. C. M.	67.8	90.5	96.0	52.8	96.0
812	W. O'C.	41.6	87.4	96.4	32.2	97.2
Average		52.8	90.4	96.0	51.4	96.8

The subjects ate on an average 23 grams of protein, 59 grams of fat, and 416 grams of carbohydrate daily. The digestibility of these food constituents was found to be 52.8 per cent for protein, 90.4 per cent for fat, and 96 per cent for carbohydrate. The estimated digestibility of oleo oil alone was 96.8 per cent, which is somewhat higher than the digestibility (93 per cent) previously reported for beef tallow,[1] which contains the oleo stearin as well as the oleo oil.

The subjects reported no ill effects from the test periods with oleo oil. The coefficient of digestibility of oleo oil, 96.8 per cent, as obtained in the above experiments, is practically identical with the reported [2] coefficients of digestibility of the common animal and vegetable fats, which, on the average, are 97 per cent.

OLEO STEARIN.

Oleo stearin, which is obtained as outlined above, is ordinarily a white, odorless, tasteless fat, solid at ordinary room temperature. It is quite extensively used in the manufacture of compounded edible fats commonly known as lard substitutes and lard compounds, but has relatively little if any use in the home as such for culinary purposes.

A supply of oleo stearin sufficient for the purpose of this study was obtained from a dealer who was able to supply it in quantity, and it was known to be typical of commercial oleo stearin.

Three experiments were made to determine the digestibility of oleo stearin, and the data obtained are tabulated on page 16.

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[1] U. S. Dept. Agr. Bul. 310 (1915), p. 21.

[2] See list on page 26.

Data of digestion experiments with oleo stearin in a simple mixed diet.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 825, subject J. F. C.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing oleo stearin	1,164.0	528.3	20.4	198.6	410.9	5.8
Wheat biscuit	278.0	25.0	29.5	4.2	214.9	4.4
Fruit	856.0	743.9	6.8	1.7	99.3	4.3
Sugar	142.0				142.0	
Total food consumed	2,440.0	1,297.2	56.7	204.5	867.1	14.5
Feces	153.0		33.6	61.6	44.5	13.3
Amount utilized			23.1	142.9	822.6	1.2
Per cent utilized			40.7	69.9	94.9	8.3
Experiment No. 827, subject T. G. H.:						
Blancmange containing oleo stearin	1,012.0	459.3	17.7	172.7	357.2	5.1
Wheat biscuit	39.0	3.5	4.1	0.6	30.2	0.6
Fruit	617.0	536.2	4.9	1.2	71.6	3.1
Sugar	167.0				167.0	
Total food consumed	1,835.0	999.0	26.7	174.5	626.0	8.8
Feces	92.0		17.0	36.7	31.7	6.6
Amount utilized			9.7	137.8	594.3	2.2
Per cent utilized			36.3	79.0	94.9	24.7
Experiment No. 828, subject F. K.:						
Blancmange containing oleo stearin	1,317.0	597.8	23.0	224.7	464.9	6.6
Wheat biscuit	467.0	42.0	49.5	7.0	361.0	7.5
Fruit	791.0	687.4	6.3	1.6	91.8	3.9
Sugar	176.0				176.0	
Total food consumed	2,751.0	1,327.2	78.8	233.3	1,093.7	18.0
Feces	199.0		43.8	78.4	61.7	15.1
Amount utilized			35.0	154.9	1,032.0	2.9
Per cent utilized			44.4	66.4	94.4	16.6
Average food consumed per subject per day	780.6	402.6	18.0	68.0	281.8	4.6

Summary of digestion experiments with oleo stearin in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of oleo stearin alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
825	J. F. C.	40.7	69.9	94.9	8.3	76.6
827	T. G. H.	36.3	79.0	94.9	24.7	89.8
828	F. K.	44.4	66.4	94.4	16.6	73.9
Average		40.5	71.8	94.7	16.5	80.1

On an average the daily diet supplied 18 grams protein, 68 grams fat, and 281.8 grams carbohydrate, the energy value being 1,811 calories.

Considering the digestibility of the ration as a whole on an average the subjects digested 40.5 per cent of the protein, 71.8 per cent of the fat, and 94.7 per cent of the carbohydrate. The estimated digestibility of the oleo stearin alone is 80.1 per cent. The figure, as would naturally be expected, is considerably lower than that of oleo oil, 96.7 per cent, and also lower than 93 per cent, the digestibility of beef tallow, which consists of both oleo oil and oleo stearin.

In their reports of their physical condition during the test period, the subjects noted no unusual physiological conditions.

OX-MARROW FAT.

It is believed by many people that bone marrow possesses properties which make it of particular value for food purposes and of especial value in the dietary of invalids and convalescents. That there is a scientific basis for such belief is shown by a review of the literature. In discussing the value of fat in the diet Friedenwald and Ruhrah[1] say that bone marrow, which is rich in fat, is used in the treatment of tuberculosis and pernicious anemia. The marrow of young animals is preferred, and the glycerin extract of bone marrow is utilized. Zink[2] states: "Yellow marrow contains chiefly fat which consists of olein, palmitin, and stearin, and which differs from the fat of the other parts of the body in having a higher acetyl equivalent." In a study of red marrow Forrest[3] obtained two proteins, one a globulin coagulating at 47–50° C., which contained no phosphorus, and a second a nucleo-albumin which was found to contain phosphorus in its molecule. Glikin[4] reports that iron occurs regularly in beef marrow, the marrow of young animals containing larger amounts than that of old animals. According to Halliburton[5] the most important protein of red marrow "is a nucleo-protein which contains 1.6 per cent of phosphorus." In considering the dietary value of marrow, however, it must be remembered that it contains a large amount of marrow fat and that this, like all other fats, is a valuable source of energy in addition to the special therapeutic value attributed to it. Marrow is well known as food. Common examples are marrow bones, an old-fashioned dish, and marrow balls, which are served in soup.

The preparation of marrow fat is confined very largely to the packing houses, where it is obtained from the leg bones of beef animals. The process, according to information obtained from the Bureau of Animal Industry, is as follows:

> Marrow fat is prepared from long or shank bones, they being first heated in water at a temperature of from 160° to 170° Fahrenheit. Both ends of the bones are sawed off and the marrow removed by blowing with compressed air.

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[1] Diet in Health and Disease. Philadelphia and London: W. B. Saunders Co., 1913, 4. ed., p. 144.

[2] Chem. Zentbl., 68 (1897), No. 5, p. 296.

[3] Jour. Physiol., 17 (1894–5), p. 175.

[4] Ber. Deut. Chem. Gesell., 41 (1908), No. 5, p. 910.

[5] Jour. Physiol., 18 (1895), No. 4, pp. 306–318.

It is placed in cans, being processed in the usual manner for processing canned meat products. When prepared in this manner it is put out in the trade as "ox marrow."

For the purpose of this study a supply of this fat, packed in 1-pound tins labeled "Ox-Marrow Fat," was obtained from commercial sources. In appearance it was of a yellow color, solid at room temperature, and without a characteristic odor. The fat was melted, thoroughly mixed, and a sample analyzed by R. H. Kerr, of the Bureau of Animal Industry, was found to have an iodin number of 48.48, refractive index of 47°, with a Zeiss butyro-refractometer at 40°, and 0.56 per cent of free acid.

The marrow fat was incorporated in a blancmange and eaten as a constituent of the usual simple mixed diet by four subjects. The results of the experiments are reported in the following tables:

Data of digestion experiments with ox-marrow fat in a simple mixed diet.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 692, subject P. K.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing ox-marrow fat	1,700.0	710.1	30.8	294.8	651.1	13.2
Wheat biscuit	305.0	27.4	32.3	4.6	235.8	4.9
Fruit	418.0	363.2	3.4	0.8	48.5	2.1
Sugar	136.0				136.0	
Total food consumed	2,559.0	1,100.7	66.5	300.2	1,071.4	20.2
Feces	76.0		21.1	26.0	23.2	5.7
Amount utilized			45.4	274.2	1,048.2	14.5
Per cent utilized			68.3	91.3	97.8	71.8
Experiment No. 693, subject J. C. M.:						
Blancmange containing ox-marrow fat	1,928.0	805.3	34.9	334.3	738.4	15.1
Wheat biscuit	371.0	33.4	39.3	5.6	286.8	5.9
Fruit	796.0	691.7	6.4	1.6	92.3	4.0
Sugar	122.0				122.0	
Total food consumed	3,217.0	1,530.4	80.6	341.5	1,239.5	25.0
Feces	83.0		24.8	22.9	27.5	7.8
Amount utilized			55.8	318.6	1,212.0	17.2
Per cent utilized			69.2	93.3	97.8	68.8
Experiment No. 694, subject A. A. R.:						
Blancmange containing ox-marrow fat	1,793.0	748.9	32.5	310.9	686.7	14.0
Wheat biscuit	118.0	10.6	12.5	1.8	91.2	1.9
Fruit	1,246.0	1,082.8	10.0	2.5	144.5	6.2
Sugar	122.0				122.0	
Total food consumed	3,279.0	1,842.3	55.0	315.2	1,044.4	22.1
Feces	108.0		37.7	28.7	31.9	9.7
Amount utilized			17.3	286.5	1,012.5	12.4
Per cent utilized			31.5	90.9	96.9	56.1
Experiment No. 695, subject W. E. T.:						
Blancmange containing ox-marrow fat	588.0	245.6	10.6	102.0	225.2	4.6
Wheat biscuit	313.0	28.2	33.2	4.7	241.9	5.0
Fruit	989.0	859.4	7.9	2.0	114.7	5.0
Sugar	138.0				138.0	
Total food consumed	2,028.0	1,133.2	51.7	108.7	719.8	14.6
Feces	56.0		16.6	11.6	20.5	7.3
Amount utilized			35.1	97.1	699.3	7.3
Per cent utilized			67.9	89.3	97.2	50.0
Average food consumed per subject per day	923.6	467.2	21.2	88.8	339.6	6.8

Summary of digestion experiments with ox-marrow fat in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of ox-marrow fat alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
692	P. K.	68.3	91.3	97.8	71.8	93.7
693	J. C. M.	69.2	93.3	97.8	68.8	95.6
694	A. A. R.	31.5	90.9	96.9	56.1	91.6
695	W. E. T.	67.9	89.3	97.2	50.0	93.1
Average		59.2	91.2	97.4	61.7	93.5

In the experiments reported above the subjects ate on an average 21 grams of protein, 89 grams of fat (of which 87 grams were marrow fat), and 340 grams of carbohydrate. This diet furnished approximately 2,245 calories of energy daily. It will be noted that in experiment No. 695 the subject W. E. T., who did not possess a very vigorous appetite, ate only 109 grams of fat during the three-day period. The other subjects averaged 104 grams of fat daily. The protein supplied by the diet was 59.2 per cent digested, the fat 91.2 per cent, and the carbohydrate 97.4 per cent. The figure 91.2 per cent for the digestibility of the total fat of the diet becomes 93.5 per cent for the digestibility of marrow fat alone when correction is applied for the metabolic products and undigested basal-ration fat which occurs in the ether extract of the feces.

The consumption of 100 grams of marrow fat daily for a period of three days or more evidently caused digestive disturbances since in experiment No. 692, subject P. K. reported: "Health was normal when entering on the diet. During the period experienced a slight headache and a sickish feeling." In experiment No. 693, subject J. C. M. reported: "Felt a severe weakness accompanied by cold perspiration." In experiment No. 694, subject A. A. R. reported: "Pains in head and abdomen, general feeling of weakness." In experiment No. 695, subject W. E. T. reported: "Health normal at start of diet, during diet headache with general weak feeling."

On the basis of these experiments alone, it would appear that the continued consumption of 100 grams of marrow fat daily is likely to be attended with physiological disturbances. The results of the experiments indicate, however, that this fat is as completely digested as the common animal and vegetable fats.

OX-TAIL FAT.

Ox-tail fat is separated and marketed as an edible fat to a small extent at least in this country. In reply to an inquiry regarding its commercial production, one food-packing concern states: "This fat is not a by-product with us, but is used in the preparation of our ox-tail soup. We have absolutely no means of estimating the quantities of this fat produced in this country." A second concern reports: "We produce considerable quantities ourselves, some of which we use and some of which we sell. It is more liquid than other beef fats, containing less stearin, and for this reason would be better adapted to the manufacture of oleo oil. We sell it as an edible fat, and so far as we know, it is used with other beef fats as a shortening or for other food purposes."

Even if little of the fat is marketed for food purposes, it is evident that it is not uncommonly so used when one recalls that it is a constituent of freshly made and canned ox-tail soup.

For the purpose of this study a sufficient quantity of ox-tail fat was secured from a concern which did not include the ox-tail fat in the ox-tail soup which it packed. In appearance the fat was a cream white solid when chilled. At ordinary room temperature the fat separated into two layers, about four-fifths being a pale yellow solid and about one-fifth a light yellow oil. The fat possessed no pronounced odor or flavor. An examination[1] showed it to have the following characteristics: Index of refraction at 40° C., 49.0°; iodin number, 56.58; and melting point 37.0° to 36.8°.

Three subjects assisted in the study of the digestibility of ox-tail fat and the data obtained are reported in the tables which follow:

Data of digestion experiments with ox-tail fat in a simple mixed diet.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 704, subject P. K.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing ox-tail fat	1,814.0	824.3	35.9	227.1	711.8	14.9
Wheat biscuit	302.0	27.2	32.0	4.5	233.5	4.8
Fruit	545.0	473.6	4.4	1.1	63.2	2.7
Sugar	251.0	....	....	....	251.0	....
Total food consumed	2,912.0	1,325.1	72.3	232.7	1,259.5	22.4
Feces	58.0	....	17.8	13.7	21.0	5.5
Amount utilized	....	....	54.5	219.0	1,238.5	16.9
Per cent utilized	....	....	75.4	94.1	98.3	75.5
Experiment No. 705, subject J. C. M.:						
Blancmange containing ox-tail fat	2,004.0	910.6	39.7	250.9	786.4	16.4
Wheat biscuit	399.0	35.9	42.3	6.0	308.4	6.4
Fruit	825.0	716.9	6.6	1.7	95.7	4.1
Sugar	148.0	....	....	....	148.0	....
Total food consumed	3,376.0	1,663.4	88.6	258.6	1,338.5	26.9
Feces	86.0	....	26.0	13.0	38.2	8.8
Amount utilized	....	....	62.6	245.6	1.300.3	18.1
Per cent utilized	....	....	70.7	95.0	97.2	67.3

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[1] Analysis submitted by meat inspection laboratories of Bureau of Animal Industry.

Data of digestion experiments with ox-tail fat in a simple mixed diet—Contd.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 706, subject A. A. R.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing ox-tail fat	1,537.0	698.4	30.5	192.4	603.1	12.6
Wheat biscuit	244.0	21.9	25.9	3.7	188.6	3.9
Fruit	1,192.0	1,035.8	9.5	2.4	138.3	6.0
Sugar	118.0				118.0	
Total food consumed	3,091.0	1,756.1	65.9	198.5	1,048.0	22.5
Feces	115.0		14.7	20.2	69.4	10.7
Amount utilized			51.2	178.3	978.6	11.8
Per cent utilized			77.7	89.8	93.4	52.4
Average food consumed per subject per day	1,042.1	527.2	25.2	76.6	405.1	8.0

Summary of digestion experiments with ox-tail fat in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of ox-tail fat alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
704	P. K.	75.4	94.1	98.3	75.5	96.3
705	J. C. M.	70.7	95.0	97.2	67.3	98.2
706	A. A. R.	77.7	89.	93.4	52.4	95.4
Average		74.6	93.0	96.3	65.1	96.6

The daily diet supplied on an average 25.2 grams protein, 76.6 grams fat, and 405.1 grams carbohydrate, the energy value being 2,411 calories.

The average digestibility of the diet as a whole was found to be 74.6 per cent for protein, 93 per cent for fat, and 96.3 per cent for carbohydrate when 25 grams of protein, 77 grams of fat, and 405 grams of carbohydrate were eaten daily. The estimated digestibility of ox-tail fat alone was found to be 96.6 per cent when the usual correction was made for the metabolic products and undigested basal-ration fat occurring in the ether extract of the feces.

In reports of their physical condition during the test period, the subjects made no reference to any laxative effect resulting from the diet, and accordingly it is assumed that the limit of tolerance for ox-tail fat is in excess of 84 grams daily, the amount eaten by one of the subjects, J. C. M., for the three-day test period.

In so far as these experiments are concerned, it would appear that ox-tail fat, which is quite completely digested and does not produce physiological disturbances when eaten in normal amounts, should prove a satisfactory source of energy for the dietary whether eaten as a separate fat or as a constituent of ox-tail soup.

It has often been noted that fats from the different parts of the body possess different chemical and physical characteristics. In this connection it is interesting to note the values obtained for the digestibility of the different beef fats reported in this and other bulletins of this series which were for beef tallow[1] 93 per cent, beef-brisket fat[2] 97.4 per cent, hard-palate fat 93.7 per cent, ox-marrow fat 93.5 per cent, and ox-tail fat 96.6 per cent. These values would, of course, be more directly comparable had it been possible to secure a sufficient supply of these different fats from a single animal.

TURTLE FAT.

The flesh of the green turtle (*Chelonia mydas*), a sea turtle which lives mostly in deep water and feeds largely upon vegetable matter, is used considerably for food. The portion of the flesh known as "califash" adhering to the upper shell, has a high oil content, is of a dull greenish color, and is very highly prized, being used in the preparation of turtle soup. According to Ditmar[3] the name green turtle is due to the greenish color of the oil.

The experiments which follow were conducted to secure data concerning the extent to which green-turtle fat is utilized by the body. Through the courtesy of R. L. Coker of the United States Bureau of Fisheries, several cans of so-called turtle fat were secured from a Florida dealer. On opening, the cans were found to contain a dull greenish substance, the "califash," resembling liver in appearance, and surrounded by small quantities of a yellow oil which had separated from it. For the sake of uniformity with other experiments, the canned turtle fat was rendered and fed in the same way as other fats studied. In order to secure as much of the oil as possible, the mass was passed through an ordinary household meat cutter and was rendered by heating in a double boiler. The resulting oil was of a yellow color without any noticeable odor.

Four three-day digestion tests were made of green-turtle fat and the results which were obtained are reported in the tables which follow.

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[1] U. S. Dept. Agr. Bul. 310 (1915), p. 21.
[2] U. S. Dept. Agr. Bul. 507 (1917), p. 18.
[3] Reptiles of the World. New York: Sturgis and Walton, p. 14.

Data of digestion experiments with green-turtle fat in a simple mixed diet.

Experiments, subjects, and diet.	Weight of foods.	Constituents of foods.				
		Water.	Protein.	Fat.	Carbohydrate.	Ash.
Experiment No. 681, subject A. F.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing green-turtle fat	1,933.0	890.0	34.0	174.2	821.7	13.1
Wheat biscuit	378.0	34.0	40.1	5.7	292.2	6.0
Fruit	657.0	570.9	5.3	1.3	76.2	3.3
Sugar	227.0				227.0	
Total food consumed	3,195.0	1,494.9	79.4	181.2	1,417.1	22.4
Feces	73.0		21.4	10.0	32.4	9.2
Amount utilized			58.0	171.2	1,384.7	13.2
Per cent utilized			73.0	94.5	97.7	58.9
Experiment No. 682, subject P. K.:						
Blancmange containing green-turtle fat	1,703.0	784.1	30.0	153.4	723.9	11.6
Wheat biscuit	338.0	30.4	35.8	5.1	261.3	5.4
Fruit	368.0	319.8	3.0	0.7	42.7	1.8
Sugar	164.0				164.0	
Total food consumed	2,573.0	1,134.3	68.8	159.2	1,191.9	18.8
Feces	79.0		26.3	11.6	34.3	6.8
Amount utilized			42.5	147.6	1,157.6	12.0
Per cent utilized			61.8	92.7	97.1	63.8
Experiment No. 683, subject J. C. M.:						
Blancmange containing green-turtle fat	1,377.0	634.0	24.2	124.1	585.4	9.3
Wheat biscuit	321.0	28.9	34.0	4.8	248.1	5.2
Fruit	780.0	677.8	6.2	1.6	90.5	3.9
Sugar	143.0				143.0	
Total food consumed	2,621.0	1,340.7	64.4	130.5	1,067.0	18.4
Feces	105.0		29.7	7.5	59.9	7.9
Amount utilized			34.7	123.0	1,007.1	10.5
Per cent utilized			53.9	94.2	94.4	57.1
Experiment No. 684, subject A. A. R.:						
Blancmange containing green-turtle fat	1,180.0	543.3	20.8	106.3	501.6	8.0
Wheat biscuit	159.0	14.3	16.9	2.4	122.9	2.5
Fruit	1,139.0	989.8	9.1	2.3	132.1	5.7
Sugar	396.0				396.0	
Total food consumed	2,874.0	1,547.4	46.8	111.0	1,152.6	16.2
Feces	76.0		27.3	9.1	32.4	7.2
Amount utilized			19.5	101.9	1,120.2	9.0
Per cent utilized			41.7	91.8	97.2	55.6
Average food consumed per subject per day	938.5	459.8	21.6	48.5	402.4	6.3

Summary of digestion experiments with green-turtle fat in a simple mixed diet.

Experiment No.	Subject.	Digestibility of entire ration.				Estimated digestibility of green-turtle fat alone.
		Protein.	Fat.	Carbohydrate.	Ash.	
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
681	A. F.	73.0	94.5	97.7	58.9	98.3
682	P. K.	61.8	92.7	97.1	63.8	97.5
683	J. C. M.	53.9	94.2	94.4	57.1	100.0
684	A. A. R.	41.7	91.8	97.2	55.6	98.4
Average		57.6	93.3	96.6	58.9	98.6

On an average the four subjects who assisted in the study of the digestibility of turtle fat ate 22 grams of protein, 49 grams of fat, and 402 grams of carbohydrate daily. The digestibility of the diet as a whole was found to be, for protein 57.6 per cent, for fat, 93.3 per cent, and for carbohydrate, 96.6 per cent. When allowance is made for metabolic products and undigested fat resulting from the basal ration, the figure, 93.3 per cent, for the digestibility of the total fat of the diet, becomes 98.6 per cent for the digestibility of turtle fat alone. In reports of their physical condition the subjects made no reference to any laxative effect or other digestive disturbance resulting from the diet. Accordingly, it may be assumed that green-turtle fat taken in quantities not exceeding 50 grams daily is well tolerated and very completely assimilated by the body.

SUMMARY.

As a group the fats which are considered in the present paper are not extensively used in the home as separate fats, but all are included to a greater or less extent in the American dietary. Two of them, oleo oil and oleo stearin, find large commercial uses in the manufacture of fats for domestic consumption, oleo oil being used in the manufacture of oleomargarin and oleo stearin in the manufacture of shortening fats. Since little, if any, information was available regarding the extent to which they are utilized by the human body, their coefficients of digestibility were determined and found to be 98.4 per cent for goat's butter, 95.3 per cent for kid fat, 93.7 per cent for hard-palate fat, 93.9 per cent for horse fat, 96.8 per cent for oleo oil, 80.1 per cent for oleo stearin, 93.5 per cent for ox-marrow fat, 96.6 per cent for ox-tail fat, and 98.6 per cent for turtle fat.

The studies of the digestibility of fats here reported include four experiments with goat's butter, three experiments with kid fat, three experiments with hard-palate fat, three experiments with horse fat, eight experiments with oleo oil, three experiments with oleo stearin, four experiments with ox-marrow fat, three experiments with ox-tail fat, and four experiments with green-turtle fat.

The subjects ate per day on an average 42.8 grams of goat's butter, 59.7 grams of kid fat, 87.7 grams of hard-palate fat, 62.9 grams of horse fat, 56.8 grams of oleo oil, 66.2 grams of oleo stearin, 86.8 grams of ox-marrow fat, 74.5 grams of ox-tail fat, and 46.5 grams of turtle fat.

In the reports of their physical condition during the test periods, the subjects did not note any physiological disturbances except in the case of ox-marrow fat, which seemed to have a slight laxative effect. No evidence was secured as to whether this condition resulted from the nature of the fat or from the fairly large amount ingested daily.

The protein and carbohydrate eaten during the test periods with the fats studied in these experiments were derived from the same foods as in the experiments reported in previous bulletins. The coefficients of digestibility for total protein were 72 per cent in the goat's butter tests, 88 per cent in the kid-fat tests, 50.9 per cent in the hard-palate fat tests, 60 per cent in the horse-fat tests, 52.8 per cent in the oleo-oil tests, 40.5 per cent in the oleo-stearin tests, 59 per cent in the ox-marrow fat tests, 75 per cent in the ox-tail fat tests, and 58 per cent in the turtle-fat tests. The coefficients of digestibility for total carbohydrate were 97.3 per cent in the goat's butter tests, 95 per cent in the kid-fat tests, 97.6 per cent in the hard-palate fat tests, 96 per cent in the horse-fat tests, 96.0 per cent in the oleo-oil tests, 94.7 per cent in the oleo-stearin tests, 97 per cent in the ox-marrow fat tests, 96 per cent in the ox-tail fat tests, and 97 per cent in the turtle-fat tests. The above coefficients of digestibility of protein and carbohydrate supplied by the diet as a whole indicate that the fats under consideration did not decrease the assimilation of these constituents.

On the basis of the experiments here reported it is evident that goat's butter, kid fat, hard-palate fat, horse fat, oleo oil, oleo stearin, ox-marrow fat, ox-tail fat, and turtle fat when eaten in amounts equivalent to the amount of butter eaten in the normal dietary are well assimilated, and judged by this and what is known of their use as food fats, should prove wholesome sources of fat for human consumption.

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